UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

Air Force Research Laboratory

Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio Spring 2006

Biofuel Powered Heated Vest Developed

The Air Force Research Laboratory's Materials and Manufacturing Directorate (AFRL/ML), in collaboration with Vacca Inc., and in consultation with the Army Natick Soldier Center, financed the development of a low-cost, lightweight heated vest. Using methanol or ethanol fuel, the vest provides enduring heat to military personnel.

Around the world, military personnel from Alaska to Afghanistan operate in harsh, frigid environments. Temperatures in the Afghani Mountains have been recorded as low as –51°F, while Elmendorf Air Force Base, Alaska sees up to 69 inches of snowfall each year and many bases have much more snow than this.

Military personnel must have user-friendly, affordable and enduring protection from inclement weather conditions. In searching for a solution, ML evaluated several methods to maintain a healthy body temperature in these colder climates by conducting market research and consulting with AFRL's Propulsion Directorate, the Army Natick Soldier Center, OnPoint Technologies and the Air Force's Force Protection Battlelab. Vacca Incorporated's biofuel powered flameless catalytic heaters showed significant promise in meeting military personnel's cold weather needs. Through the Company Grade Officer Initiative, ML funded the integration of the heaters into a vest.

The lightweight, easy-to-use prototype combines a standard work vest with two of Vacca Incorporated's biofuel powered heaters in the two front panels of the vest. Using fuel cell concepts developed at Los Alamos National Laboratories, Vacca Incorporated. developed heaters that work by passing methanol or ethanol across a catalyst membrane. The reaction byproducts are heat, carbon dioxide, and small traces of water. Currently weighing only 12 ounces, and having the potential to weigh 8 ounces in future designs, the prototype weighs dramatically less than the 1.7 pound commercial products on the market today.

The prototype provides enduring heat and comfort over existing approaches. The 15-piece cold weather uniform, currently worn by military personnel, can be bulky and cumbersome to wear and carry. Additionally, these individuals are at greater risk when they must take off body armor to add or remove layers of clothes. Commercially introduced lithium ion heated jackets provide heat for 2.5-3 hours before recharging the battery. In contrast, Vacca Incorporated's revolutionary prototype, according to the company's final report, can last 22 hours with 100cc of fuel in low heat mode (22 Watt) and 12 hours in high heat mode (42 Watt). The vest's internal fuel supply has high/low/off settings for increased control.

Both the vest and fuel are much more affordable to the Department of the Defense compared to the available commercial products. Current commercial products (continued on page 2)

Top: biofuel powered heaters in the two front panels of a vest. Right: Senior Airman Bradley Cogan (left) and Senior Airman Ryan Perry (Center), of the 88th Security Forces Squadron, observe as 1st Lt. Brian Smith, of the Air Force Research Laboratory Materials and Manufacturing Directorate, demonstrates the new heated vest technology.

Air Force Develops Environmentally Compliant Corrosion Protection

Scientists and engineers from the Air Force Research Laboratory's Materials and Manufacturing Directorate (AFRL/ML) led the development of a non-chromated primer for aluminum aircraft surfaces and structures.

This non-chromated primer is the result of a collaborative effort between the directorate, the University of Missouri-Rolla, Deft Coatings, and Warner-Robbins Air Logistics Center. The first operational F-15 was painted with this primer in August, and the entire F-15 fleet will convert to the primer coating as they arrive for regularly scheduled depot refurbishment.

Due to the excellent corrosion inhibiting properties of chromates, chromate-based surface treatments, primers and inhibitors have been used to control and mitigate corrosion in Air Force aircraft. However, hexavalent chrome, the method currently used by the Air Force, is a known carcinogen that environmental and health regulations have designated as hazardous. This requires careful handling and additional disposal expense and imposes additional health risks to personnel. Though a variety of non-chromium based primers have been developed and evaluated, never before has a primer offered corrosion protection equal to the chromium-based treatments.

In 1992, the Air Force Office of Scientific Research sponsored a research grant at the University of Missouri-Rolla (UMR) to explore the viability of rare earth compounds to inhibit the corrosion of aluminum alloys. After several years of promising exploration, ML initiated a research and development program with UMR in 1999.

This program developed a chrome-free inhibitor technology that was further developed into paint formulations and a primer coating. Boeing Phantom Works, in St. Louis, MO, was used as a subcontractor to provide assessments as well as guide the university to transition a product. During the simulated environment assessments, the coating was found to work just as effectively as a chromate based treatment.

Deft primer applied to an F-15

After the assessments, UMR partnered with Deft Coatings, of Irvine, CA, and subsequently licensed their technology for production. The F-15 Systems Group, at Warner-Robbins AFB, GA, became interested in using the non-chromated primer to reduce hazardous wastes and personnel exposure. A Boeing production model F-15C was painted with the environmentally compliant primer manufactured by Deft for a trial. As a result, the F-15 Systems Group has subsequently approved the use of this coating, marking the first fleet of Air Force aircraft using a non-chromated primer coating.

Development of an environmentally safe, non-chromated primer coating for aluminum aircraft structures is one of several Air Force initiatives concerned with providing aircraft with advanced corrosion protection that is environmentally friendly. Replacing existing chromate containing treatments is expected to eliminate 90 percent of the Air Force's hazardous waste stream and to reduce costs associated with handling and disposal of the current chrome-based treatments, which are carcinogenic. This not only reduces the amount of hazardous wastes generated by the Air Force, but more importantly, protects airmen from exposure to these dangerous chemicals.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-479.

VISIT US AT WWW.AFRL.AF.MIL

(continued from page 1)

cost over $500 per unit, while the full-scale version of Vacca Incorporated's technology will cost $150-$250. Market rates for methanol fuel are between $3 and $5 a gallon.

The prototypes purchased by ML are currently being used to demonstrate the feasibility of the technology. With additional funding to develop flexible heaters, user-friendly fuel storage and a robust heat distribution system, the product could be ready for launch by 2007.

The heated vest enhances an individual's agility in the field through a 50 percent reduction in cold weather gear. It aids a person's ability to maintain normal body temperature in harsh winter environments. The technology revolutionizes weight and efficiency of the heated garment market.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-462.

Friction Stir Welding Provides Advantages Over Conventional Fusion Welding Process

During the last several years, a team of scientists from the Air Force Research Laboratory Materials and Manufacturing Directorate have been conducting ground breaking research using a revolutionary process to join structural metal alloys used to build aircraft, civil structures, and other major assemblies.

The process, known as friction stir welding (FSW), is an efficient and cost-effective alternative to fusion welding, routinely used for joining structural alloys including those used to build military aircraft. The researchers tested FSW effects on the microstructure and fatigue of a number of high strength aluminum and aluminum-lithium alloys including one of the principal alloys, 7050-T7451, used in military and commercial aircraft construction. The data gained from this research effort is helping determine how and when FSW can be used to reduce aerospace manufacturing costs for the Air Force, Department of Defense, and commercial aerospace.

The aerospace industry uses significant amounts of fastener technology to join metallic structures. It is well known, for example, that a large cargo aircraft or a large commercial airliner has millions of fasteners. Thus, elimination of fasteners would provide considerable weight savings. Researchers at the Materials and Manufacturing Directorate (ML) Metals, Ceramics and Nondestructive Evaluation (NDE) Division (Dr. Kumar Jata, Dr. Lee Semiatin and Dr. Reji John) completed in-house FSW investigations in which many aerospace aluminum alloys, including 7050-T7451, widely used in military and commercial aircraft manufacturing, were friction stir welded to assess FSW effects on microstructure and mechanical properties.

ML researchers are further expanding the knowledge of microstructure-property relationships, corrosion and failure modes, and life cycle benefits in friction stir welds. Additionally, databases and process specifications are being developed so that desirable and predictable properties can be consistently achieved, and the FSW process can be qualified for use in manufacturing components for transportation systems and reusable cryotank applications for space.

The automotive, aircraft, space, and ship-building industries along with the USAF are vigorously pursuing FSW technology to join not only aluminum alloys but steels and recently, titanium alloys. Research is progressing at a vigorous pace on all fronts, including novel tool design, optimization of process parameters to produce mechanical properties equal to or better than fastened structures, and process models to understand and guide the FSW process. Further advancements in FSW could lead to cost-effective ways for repairing defects in metal surfaces without changing the original structures.

FSW offers many advantages over conventional fusion welding, including welding of difficult-to-weld aluminum alloys (particularly the 7xxx series widely used by aircraft manufacturers), better retention of baseline material properties, fewer welding defects, lower residual stresses, and improved dimensional stability of the welded structure. With FSW, the material being welded doesn't melt or recast. As a result, material transformations that occur during the cool down of the weld are in solid-state. FSW is devoid of gases normally accompanying fusion welding, and joins aluminum alloys fairly rapidly, at about four millimeters per second, with low heat input and without shielding gases and costly filler materials.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-378.

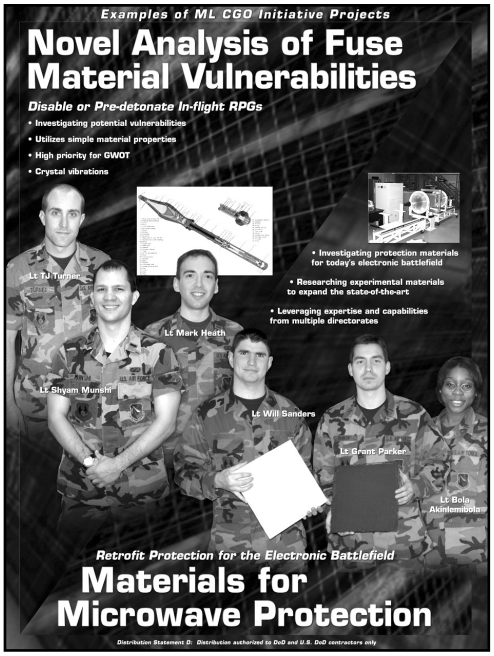
ML Takes Advantage of CGO Initiative Program

The Air Force Research Laboratory Materials and Manufacturing Directorate has a Company Grade Officer Initiative Program (CGOIP) which gives young researchers important opportunities.

The program is unique to ML and was established in 2002, by former director Dr. Charles Browning. The program provides Company Grade Officers (CGO), which include lieutenants and captains, the opportunity to work on a special project outside their Core Technology Area. The program serves three purposes: to develop lieutenants and captains through "hands-on" experience, mentorship and ownership of a project; to add to the overall science and technology knowledge base; and to develop a technological solution to a military need.

To be a part of the program, the CGO comes up with an area that he or she is interested in exploring, whether it is the development of a material, the modification of a product with military application potential, or the development of a technology prototype. The CGO then prepares a paper that details the intended project, the specific need that it will fulfill, a list of experts that they plan to consult, as well as potential collaborators and teammates, an experimental plan and the estimated cost. The paper is then submitted to the current director, Colonel Timothy Sakulich, for review and approval. Projects usually last 6 to 12 months and involve an investment of $50,000 to $100,000. After the funding is granted, the CGO enters into a contract and begins the work. The CGO may consult with the CGOIP project officer or focal point, 1st Lt Shyam Munshi. Lieutenant Munshi provides guidance to help further the projects where needed.

(continued on page 4)



(continued from page 3)

"The CGO Initiative Program is a phenomenal junior force developmental tool," said Lieutenant Munshi, who recently explained the program to University of Iowa Reserve Officer Training Corps students. "It gives young officers the chance to take ownership of the management and development of higher risk technology, from idea to reality."

The program has been responsible for the successful development of technologies that show strong promise in the field. For example, the Lightweight Body Armor project has produced a lighter product while increasing ballistic protection; the Identification of Friend or Foe system uses a flexible fiber optic woven cloth to help identify soldiers in the field to avoid friendly fire incidents; and ALON Transparent Armor that has the same stopping power as the standard armor, but at almost half the weight. Although none of these have moved in to mass production, the first two have items in the field.

During the 2005 Scientific Advisory Board (SAB) Review, the ML SAB called the CGO Initiative Program "a model of success for the entire AFRL." ML was asked to deliver a briefing on the program to the AFRL Manpower and Personnel Sub-Committee, which is composed of the AFRL Technical Directorate Directors and other high level staff.

The USAF Materials Technology Highlights is published quarterly to provide information on materials research and development activities by Air Force Research Laboratory's Materials & Manufacturing Directorate. For more information on subjects covered in "Highlights" or to be added to the "Highlights" mailing list, contact the Materials & Manufacturing Directorate Technology Information and Support Center at (937) 255-6469 or e-mail at techinfo@afrl.af.mil. Approved for Public Release (AFRL/WS#06-0696).

UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

AFRL/MLOB-TISC BLDG. 653
2977 HOBSON WAY, ROOM 406
WRIGHT-PATTERSON AFB OH 45433-7746

OFFICIAL BUSINESS